DOCUMENT RESUME

ED 177 018 SE 029 182

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TITLE Measuring Diagnostic/Remedial Competence in Teaching Elementary School Mathematics.
PUB DATE [78]
NOTE 25p.

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Clinic Personnel (School); Educational Diagnosis; Elementary Education; *Elementary School Mathematics; *Elementary School Teachers; *Measurement Instruments; Remedial Instruction; Remedial Mathematics; *Special Education Teachers; Teacher Behavior; Teacher Education; *Teacher Evaluation

ABSTRACT

Presented is an instrument that can be used to determine the competence of regular classroom teachers, special-education teachers, or clinicians in the area of diagnosis and remedial instruction in elementary mathematics. The instrument itself, an answer form, background and theoretical development of the instrument, reliability and validity data, scoring details, and a sample demonstrating the techniques for scoring are included. (Author/MK)

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Measuring Diagnostic/Remedial Competence in Teaching Elementary School Mathematics

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SE 029 182

Abstract

This paper presents an instrument that can be used to determine the competence of regular classroom teachers, special-education teachers, or clinicians in the area of diagnosis and remedial instruction of elementary mathematics. The instrument itself, an answer form, background and theoretical development of the instrument, reliability and validity data, scoring details, and a sample demonstrating the techniques for scoring are included.

Measuring Diagnostic/Remedial Competence in Teaching Elementary School Mathematics

Without long-range observation and extensive testing, determining teacher competence in diagnosing and remediating mathematics learning problems in the elementary school classroom is a difficult problem. The importance of such competence for teachers has been repeatedly emphasized (Commission, 1973; Glennon and Callahan, 1968; West, 1971; Finding, 1972). Teachers need to be able to identify specific aspects of mathematics which are causing a child difficulty, and, in response, design meaningful sequences of instruction. The purpose of this paper is to present an instrument for measuring teacher's diagnostic/remedial skills.

In some ways, the development of such an instrument is related to deciding who is a good teacher. In the past, "good teaching" and the "good teacher" were usually defined, if defined at all, in terms of the attributes which teachers possessed prior to the teaching act--personality, knowledge, years of teaching experience, the number of professional meetings attended, etc. (Millman, 1971). Medley (1973) indicated that the prevailing point of view of early research was that "anyone can recognize a good teacher" or at least that "experts" (e.g., professors of education or school principals) can; unfortunately, there was much disagreement, both in general and among the "experts," as to who the "good teachers" were.

According to Drophin (1973), part of the problem in deciding who is a good teacher has to do with confusion over the difference between competence and effectiveness. The Random House Dictionary of the English Language (1970) defines effectiveness as "adequate to accomplish a purpose; producing the intended or expected result" and competence as "having suitable of sufficient skill, knowledge, experience, etc., for some purpose; properly qualified." A surgeon, thus, can be competent, but if his patient dies, he is not effective.

An instrument for determining diagnostic and remedial skills, such as the one proposed in this paper, is not concerned directly with teacher effectiveness, but rather with teacher competence. It is accepted by the writers of this paper that while competence in diagnostic/remedial skills is not sufficient for diagnostic/remedial effectiveness, in the vast majority of cases, an effective teacher must first be competent.

Teacher competence includes a variety of things, among them training, experience, etc. In the past, attempts to predict student growth on the basis of competencies of the teacher have generally been unsuccessful (Heath and Nielson, 1974), perhaps because they have been limited to single dimensions of competence, for example, knowledge of subject matter to be taught. In response to these studies, Donald Medley (1973) has suggested a dynamic definition of competence in a teacher. He states that a competent teacher can be recognized not so much by what he does, but by when he does it, not by which competencies he possesses,

but by how many there are. When investigating teacher competencies, then, one should consider variety and application as well as individual skills.

The purpose of the instrument presented in this paper is to determine teacher's competencies (i.e., skills) relevant to diagnostic/remedial situations in mathematics teaching.

Theory of the Instrument

In this instrument, teacher competence in diagnostic/remedial situations is conceptualized as two basic skills. Operationally, each of these skills is associated with certain theoretical notions; when the teacher's self-reported moves and procedures in simulated diagnostic/remedial situations are interpreted as being consistent with these theoretical notions, his possession of the stated skill is assumed. It should be recognized that acceptance of alternate theoretical notions would change the scoring of the instrument, but that its basic form would remain unchanged.

The first and perhaps most important diagnostic/remedial skill needed by a teacher is the ability to correctly identify the mathematical learning difficulty the child is experiencing. The child might be having problems in mathematics simply because one or more basic arithmetic facts are missing from his background or because he has forgotten part or all of an algorithm. On the other hand, his problem might be related to a missing

concept. In more severe cases, there may be many missing concepts and facts. The problem for the teacher is to correctly identify these facts and concepts on the basis of his diagnosis.

Once the learning difficulty has been identified, a second skill is necessary--the ability to design instruction appropriate to the child's problem. If the child does not understand the concept of multiplication, for example, drilling him on the multiplication facts would be inappropriate.

William Brownell (1947) has argued that appropriate instruction is that which is "meaningful" to the child. Research has suggested that meaningful instruction leads to greater competence in computational skills as well as greater transfer of learning (Dawson and Ruddell, 1955).

According to Robert Gagne (1970), one aspect of meaningful instruction involves teaching a topic in a hierarchical manner, starting at the pupil's level of understanding proceeding from there. This entails task analysis--deciding what the child needs to know in order to carry out the desired operation. For example, in order to multiply (with understanding) a two-digit number by a one-digit number where regrouping (carrying) is involved, the child must know the meaning of the numerals; he must understand place value; he must be able to add multi-digit numbers; he must be able to regroup; he must be able to apply the distributive property, etc. If any of these concepts or skills is missing from his background, the child will either be unable to do the problem or he will

carry it out at a rote level, perhaps obtaining a "correct" answer without understanding the process.

According to Jerome Bruner (1971), a child's knowledge of the world is first based on his active experiences with the real world (enactive level). Next he takes a step toward abstracting his environment and is able to manipulate mental images of the concrete world (iconic level). Finally, the child frees his mind from dependency on concrete situations and is able to manipulate ideas in his mind using numeric symbols or language (symbolic level). Applying this theory to mathematics instruction for young children, a sequence of experiences generally progressing from the concrete to the pictorial and finally to the symbolic levels would seem to be appropriate. For example, before expecting children to work with the concept of addition at an abstract level, they should first have many experiences joining together sets of objects concretely and pictorially. Similarly, experiences designed to teach the concept of place value might involve first bundling and unbundling counting sticks, then drawing pictures of the sticks, and finally replacing the drawings with numbers. A second aspect of meaningful instruction, then, appears to involve all three of Bruner's levels of representation.

A third aspect of meaningful instruction has to do with the qualitative level of communication between the child and the teacher. At one extreme is instruction at a rote level where the teacher simply lists a sequence of steps that the child must carry out in order to arrive at a

correct solution. A more meaningful level of communication might involve a verbal explanation which takes into consideration the child's ability to understand mathematical language as well as his background in mathematics or demonstrating the procedure at one or more of Bruner's three levels. The highest level of communication would be two-way, perhaps involving probing questions or carefully guided "discovery" of concepts.

In general, then, the classroom teacher with diagnostic/remedial competence would be expected to modify a directive asking him to teach a certain subject on a certain date, adapting it to fit the needs of the class. One would expect such a teacher to attempt to meet the needs of each of his students, testing each one to find his level of knowledge and adjusting the sequence of instruction and level of communication to make them meaningful for each child. The teacher would be expected to involve the child in experiences at all three of Bruner's levels, using a variety of activities (such as games and real-world applications) in order to keep him interested in the topic.

The Instrument

In Figure 1 a copy of the instrument is presented. Note that the test items are of the open-ended variety where the subjects are given the opportunity to respond freely to each question. An answer sheet (Figure 2) is provided to encourage fairly detailed responses.

Insert Figure 1 and Figure 2 about here

Administration: Experience has shown that the instrument is best administered in a controlled setting where the subjects are supervised and given a specified period of time to write their answers. Less valid results seem to be obtained when the subjects are allowed to take the test at their leisure, at home, by working together in a group, etc. Thirty minutes generally appears to be sufficient time for subjects to write their responses, although most of them will take less time. The only materials necessary for administration of the instrument are the instrument itself, a pen or pencil, and the answer sheet. Obviously, outside reference sources should not be allowed.

Scoring: Scoring is accomplished by assigning points to each subject based on the inferred consistency of his free responses with the identified theoretical notions. Although scoring this kind of instrument is usually more difficult than scoring a test with closed-ended questions, the writers feel that in this type of test the subjects will less likely be led into giving answers sought by the testers. It is thus felt that scoring will be more valid and will more accurately reflect the teacher's diagnostic/remedial competence.

A copy of the point distribution format and point recording sheet for scoring the instrument are shown in Figures 3 and 4, respectively. The scoring device presented in Figure 3 is divided, as is the instrument,

Insert Figure 3 and Figure 4 about here

into two parts. Part I emphasizes the teacher's classroom diagnostic/remedial techniques, while Part II emphasizes the teacher's ability to correctly diagnose the child's learning difficulty and to design an appropriate sequence of instruction. Part I has a possibility of 20 points, and each question in Part II has a possibility of 10 points--for a total of 50 possible points. A person scoring over 35 points could be considered to possess acceptable (in terms of the above-mentioned criteria) diagnostic/remedial competencies. An example of a student's responses and the way one scorer graded them are shown in Figure 5.

Insert Figure 5 about here

Validity and Reliability

In an attempt to validate the scoring device of this instrument, a group of eleven teachers were asked to respond in writing to the hypothetical situations presented in the instrument. The teachers had just begun a semester as students in a course designed to teach diagnostic/remedial skills and to give them experience as clinicians in a mathematics diagnosis/remediation clinic. Using the criteria presented earlier, a score was

determined for each teacher. Without knowledge of these results or of the form of the scoring device, the clinic director and his assistant each read the students responses and assigned a score from 0 to 50 to each student reflecting his assessment of each student's general diagnostic/remedial competence. The scores obtained from the scoring device were statistically compared with the scores obtained by the clinic director and by his assistant (see Table 1).* No significant differences (α=.05) were found between the scores obtained by the scoring device and those obtained by either the clinic director or by his assistant. These results would seem to suggest that scoring written answers to the instrument using the given scoring device will produce valid results when "validity" is defined in terms of "expert" analysis of the same written answers.

Insert Table 1 and Table 2 about here

In order to determine if different raters would obtain similar results when scoring a given teacher's written responses to the items of the instrument, the same set of eleven response sheets was graded by a second rater. No significant difference (α=.05) was found between the mean scores of the two raters (see Table 2).

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*Note: When the same instrument was administered to the teachers at the end of the semester, the scores showed an average increase of 59%.

Conclusion

In this paper an instrument for determining diagnostic/remedial competence in mathematics teaching was presented. Placed in simulated diagnostic/remedial situations, subjects are assigned scores indicating the consistency of their self-reported moves and procedures with certain theoretical notions assumed to reflect diagnostic/remedial competence. Comparison with "expert" opinions and between independent raters has suggested the instrument to be both valid and reliable.

This instrument has not been presented as the final answer for determining diagnostic/remedial competence in school mathematics. Although the writers view this instrument as a significant step, refinements and alternate conceptualizations for determining teacher competence are needed. If children experiencing learning difficulties in mathematics are to be helped, teachers must be competent in identifying children's difficulties and designing appropriate instruction. The instrument presented in this paper represents one way to determine this competence.

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Table 1

Teacher		1	2	3	4	5	6	7	8	9	10	11	Mean
Scoring Device	(A)	24	20	14	19	23	24	31	23	12	24	24	21.6364
Clinic Director	(B)	22	20	12	21	20	23	30	27	15	18	35	22.0909
Assistant	(C)	24	21	10	16	20	29	33	28	11	13	27	21.0909

$H_1: \mu_A = \mu_C$

$H_0: \mu_A = \mu_B$

$t_0 = -.179217$ df = 20 $t_{.05/20} = 2.086$

$t_1 = -.160013$

The data do not permit rejection of the null hypotheses.

Table 2

Teacher	1	2	3	4	5	6	7	8	9	10	11	Mean
1st Scorer (A)	24	20	14	29	23	24	31	23	12	24	24	21.6364
2nd Scorer (D)	26	22	17	18	23	23	33	26	13	29	17	22.4545

$H_2: \mu_A = \mu_D$

$t_2 = -.305494$ df = 20 $t_{.05/20} = 2.086$

The data do not permit rejection of the null hypothesis.

Figure Caption

Figure 1. Test items are of the open-ended variety where the subjects are given the opportunity to respond freely to each question.

Figure 2. A provided answer sheet encourages fairly detailed responses.

Figure 3. Scoring the test.

Figure 4. Score sheet.

Figure 5. Example of student's responses and the way one scorer graded them.

Name _____

Years Taught _____ Grade _____

I. If you teach in kindergarten through grade 4, answer part A below. If you teach in grade 5 or above, answer part B.

A. (K-4) You are teaching second grade. At the beginning of the school year you're given a list of topics to be covered in mathematics during the year. First on the list is addition of two-digit numbers. Describe your mathematics program during the first three weeks of class.

B. (5-) You are teaching 6th grade mathematics. At the beginning of the school year you are given a list of topics to be covered during the year. First on the list is addition of fractions. Describe your mathematics program during the first three weeks of classes.

II. For each of the following situations, (a) tell what you think could be the nature of the child's difficulty, (b) on the basis of your conjecture, tell how you would remediate the problem by listing a sequence of activities you might follow.

1. Below is a sample of a 5th grader's work. He multiplies correctly in all cases except when confronted with the products 6 X 7 and 7 X 8.

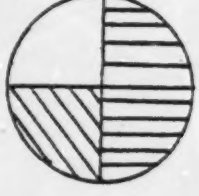
32	36	65	27	80
X 8	X 7	X 7	X 8	X 7
256	247	405	205	450

2. The pupil whose work is shown below makes a consistent mistake; he always subtracts the smaller digit from the larger, whether it is in the minuend or subtrahend.

123	50	421
-16	-16	-26
113	46	405

3. A certain junior high student is able to correctly add simple fractions, like 1/2 + 1/4, on paper, but when shown fraction circles like the one below and asked to tell what fractional part of the circle the two colored parts make together, he is unable to give a satisfactory answer.

1/2 = 2/4
+1/4 = 1/4
3/4



Name _____

Years Taught _____ Grade _____

Part I: _____

_____

_____

_____

_____

_____

_____

Part II:

1. Diagnosis: _____

_____

Remediation: _____

_____

_____

_____

2. Diagnosis: _____

_____

Remediation: _____

_____

_____

_____

3. Diagnosis: _____

_____

Remediation: _____

_____

_____

_____

I. CLASSROOM PROCEDURES (Part I)

	Score
A. Reaction to Directive:	
1. Takes directive at face value	0 points
2. Makes limited changes	1 point
3. Questions logic of request, adds to syllabus, starts with different material, etc.	2 points
Total possible, 2 points	
B. Individualization:	
1. Teaches everybody same thing at same time	0 points
2. Groups after reviewing standardized test scores	1 point
3. Permanent grouping after diagnostic testing	2 points
4. Flexible grouping and/or individualization after diagnostic testing	3 points
Total possible, 3 points	
C. Appropriateness of Instruction:	
1. Inappropriate	0 points
2. Somewhat appropriate	1 point
3. Appropriate	2 points
Total possible, 2 points	
D. Sequence of Instruction:	
1. Non-hierarchical method of instruction	0 points
2. Limited hierarchical approach	1-2 points
3. Hierarchical approach	3 points
Total possible, 3 points	
E. Mode of Instruction:	
1. Symbolic level only	0 points
2. Instruction includes but not limited to symbolic level	1 point
3. Iconic level	1 point
4. Enactive (concrete) level	1 point
(If working at kindergarten or first grade level, symbolic and perhaps also iconic level may be eliminated -- at these levels score 3 points if instruction done on concrete level)	
F. Level of Communication in Instruction:	
1. No instruction	0 points
2. Rote level	1 point
3. Explains in apparently meaningful manner or demonstrates at one or more of three modes	2 points
4. Two-way communication, or child led to discover	3 points
Total possible, 3 points	
G. Drill and Practice:	
1. None	0 points
2. Pencil and Paper--dittos or textbook	1 point
3. Pictorial, concrete or games	2-3 points
4. Variety	4 points
Total possible, 4 points	
**Total possible for classroom procedures	20 points

II. CLINICAL OR ONE-TO-ONE SETTING (Part II)

	Score
A. Diagnosis of Problem:*	
1. Incorrect diagnosis of problem.	0 points
2. Partially correct diagnosis	1 point
3. Correct diagnosis	2 points
Total possible, 10 points	
B. Appropriateness of Instruction:	
1. Inappropriate	0 points
2. Appropriate	1-2 points
Total possible, 10 points	
C. Sequence of Instruction:	
1. Non-hierarchical method	0 points
2. Limited hierarchical approach	1 point
3. Hierarchical approach	2 points
Total possible, 10 points	
D. Mode of Instruction:	
1. Symbolic only	0 points
2. Instruction at two levels (enactive-iconic, iconic-symbolic, etc.). . .	1 point
3. Instruction at all three levels	2 points
Total possible, 10 points	
E. Level of Communication:	
1. Rote level.	0 points
2. Explains in apparently meaningful manner or demonstrates at one or more of three modes.	1 point
3. Two-way communication, or child led to discover	2 points
Total possible, 10 points	
**Total possible for clinical or one-to-one setting	30 points
Total possible for Test	50 points

*The "correct" answers for the diagnostic part of the test are:

1. The child's problem probably involves the incorrect memorization of the two multiplication facts, though perhaps could involve lack of comprehension of the concept of multiplication, thus not allowing him to "figure out" these products.

2. The child's problem could involve either place value or the concept of subtraction or both. If he understands the concept of subtraction but is not able to regroup, he might subtract in whatever way he can, in this case, subtracting the smaller from the larger.

3. Apparently the child has memorized an algorithm for adding fractions, but does not understand the concept of addition of fractions and perhaps also the concept of fractions (at least at the pictorial level).

**When answering the questions on this test, most subjects do not give complete answers to every question; they often imply a procedure but do not state it explicitly, or they give a complete reply in one answer but leave it understood in the next. It is therefore often necessary when scoring the tests to read ahead or back and to interpret what the subject is saying.

SCORE SHEET	Name:
	Number of years taught:
	Grade taught most recently:

I. Classroom Procedures		
A. Reaction to directive		
B. Individualization		
C. Appropriateness of instruction		
D. Sequence of instruction		
E. Mode of instruction		
Symbolic		
Iconic		
Concrete		
F. Level of communication		
G. Drill and practice		
II. Clinical or one-to-one setting		
Question 1		
A. Diagnosis of problem		
B. Appropriateness of instruction		
C. Sequence of instruction		
D. Mode of instruction		
E. Level of communication		
Question 2		
A. Diagnosis of problem		
B. Appropriateness of instruction		
C. Sequence of instruction		
D. Mode of instruction		
E. Level of communication		
Question 3		
A. Diagnosis of problem		
B. Appropriateness of instruction		
C. Sequence of instruction		
D. Mode of instruction		
E. Level of communication		
	Total Score	

SCORE SHEET	Name:
	Number of years taught:
	Grade taught most recently:

I. Classroom Procedures			
A. Reaction to directive			1
B. Individualization			0
C. Appropriateness of instruction			1
D. Sequence of instruction			1
E. Mode of instruction	Symbolic	0	
	Iconic	0	
	Concrete	0	0
F. Level of communication			2
G. Drill and practice			2
II. Clinical or one-to-one setting			
Question 1			
A. Diagnosis of problem			2
B. Appropriateness of instruction			0
C. Sequence of instruction			0
D. Mode of instruction			0
E. Level of communication			0
Question 2			
A. Diagnosis of problem			0
B. Appropriateness of instruction			1
C. Sequence of instruction			0
D. Mode of instruction			0
E. Level of communication			0
Question 3			
A. Diagnosis of problem			2
B. Appropriateness of instruction			2
C. Sequence of instruction			1
D. Mode of instruction			2
E. Level of communication			1
		Total Score	18

Name _____

Years Taught 3 Grade 5

Part I: I would start out by making sure the children understand what a fraction is. I would then have them review the meanings of the numerator and denominator using pictures and worksheet. I would also make sure they know how to add. Then I would have them add fractions with like denominators. I would give them worksheets and some games I have for drill. This would probly take the whole 3 weeks

Part II:

1. Diagnosis: It looks like the pupil memorized the wrong products for 6x7 and 7x8

Remediation: I would tell him what the correct answer is and drill him on it. I would ask him every day at the beginning of math what the products are until he knows them.

2. Diagnosis: It looks like the student has forgotten how to subtract.

Remediation: I would tell him you can't subtract a larger number from a smaller number. To show him why I would give him a problem like 36 - 18 to solve. Next I would show him how to borrow

3. Diagnosis: It looks like the child doesn't know what a fraction is and has memorized a way of adding them

Remediation: I would have him cut up pies, circles rectangles till he understands what a fraction is. Next I would have him cut up pies and circles in different ways to show equivalent fractions. Next I would have him do problems like $\frac{1}{2} + \frac{1}{4}$ with circles.